A Framework for Environmental Management Information Systems in Higher Education

Brenda Scholtz, André P. Calitz, and Blessing Jonamu

1 Introduction

Higher Education Institutions (HEIs) have been called on not to be bystanders as the world faces increasing environmental issues and to take action and be pioneers in driving environmental sustainability into the community (Savely et al. 2007). There has been increased interest in the topics of environmental sustainability and management of environmental information at HEIs. This is particularly evident in Europe, the United States (U.S.), Asia, Australia, Canada and South America where several studies (Disterheft et al. 2012; Fonseca et al. 2011; Jones et al. 2011; Velazquez et al. 2006) have reported efforts at reducing environmental impact in HEIs. This could be as a result of the pressure which is being placed on these institutions by Environmental Protection Agencies, stakeholders, governments and non-government organisations to act responsibly towards the environment (Savely et al. 2007).

This internal and external pressure on HEIs has prompted them to follow the industry trend of developing environmental programs and systems (Bero et al. 2012). The United States of America's Environmental Protection Agency (EPA) highlighted that the environment has become everyone's business and everyone now has a right to access high quality environmental information (EPA 2009). A key factor for achieving environmental sustainability is the management of this environmental information (Bero et al. 2012; Speshock 2010). HEIs have a unique set of challenges with regards to environmental information management and these are different to industrial contexts (Bero et al. 2012; Kamal and Asmuss 2013). The benefits of having environmental information readily available include well informed and improved decision making which facilitate the reduction in the

B. Scholtz (✉) • A.P. Calitz • B. Jonamu
Department of Computing Science, Nelson Mandela Metropolitan University (NMMU), Port Elizabeth, South Africa
e-mail: brenda.scholtz@nmmu.ac.za; andre.calitz@nmmu.ac.za

J. Marx Gómez, B. Scholtz (eds.), *Information Technology in Environmental Engineering*, Springer Proceedings in Business and Economics,
DOI 10.1007/978-3-319-25153-0_3

environmental footprint of the institution, in terms of a reduction in water usage, an improvement in energy efficiency and a reduction in pollution (Jones et al. 2011). It can also raise the environmental awareness of the institution's community which includes students, staff members and external stakeholders.

According to Velazquez et al. (2006), a HEI is considered to be a sustainable institution if the institution addresses, involves and promotes the minimisation of negative environmental, economic, social and health impact of daily activities involved in the functioning of the institution. Sustainable universities have influence to the extent that they help regional or global societies to transition to a sustainable livelihood. Whilst the importance of environmental sustainability and the relevant role of environmental information management and reporting in higher education has been emphasised in HEIs, until recently Africa has been lagging behind (Bosire 2014) and research studies in this field are limited. In South Africa there is escalating pressure on HEIs to report on sustainability since the Department of Higher Education and Training recently published a government notice dictating that it is mandatory that public HEIs report on environmental impact effective from the year 2015 (Department of Higher Education and Training 2014).

Most aspects of environmental sustainability are tightly dependent on the availability and accessibility of correct and current environmental information (El-Gayar and Fritz 2006). Organisation stakeholders need access to environmental information to evaluate and assess the environmental dimension of organisational decisions, both at a managerial level and at a strategic level. Hence, environmental sustainability requires correct Environmental Information Management (EIM). However a lack of coordinated effort and poor decision making with regards to achieving environmental sustainability in HEIs has been reported in some studies (Bosire 2014; Jones et al. 2011). This poor decision making can be attributed to the lack of efficient processes, structures and information systems which support centralised environmental data sources and eliminate information silos in different departments, faculties and campuses (Bero et al. 2012; Jones et al. 2011; Velazquez et al. 2005).

The most predominant initiative to enhance environmental sustainability in HEIs is the implementation of Environmental Management Systems (EMS) at these institutions (Disterheft et al. 2012; Jones et al. 2011). The ISO 14001 standard, specified by the International Standards Organisation (ISO), defines an EMS as a part of a management system that consists of planning activities, processes, procedures and resources for developing and maintaining of environmental policies within an organisation (ISO 2004). An EMS is not a computer system but rather a set of management tools and principles designed to aid an organisation to incorporate environmental concerns in their daily business activities (Speshock 2010).

An Environmental Management Information System (EMIS) is defined by El-Gayar and Fritz (2006) as an 'organizational-technical system for systematically obtaining, processing, and making relevant environmental information available in companies'. However, several studies (Bero et al. 2012; Savely et al. 2007) show that diverse and manual systems are still evident in HEIs. Other problems include the use of paper based records for resource usage, data quality issues and lack of data and process integration (Bero et al. 2012; Scholtz et al. 2014).

Whilst several studies (Athanasiadis 2006; Bero et al. 2012; Giesen et al. 2009; Solsbach et al. 2010) have proposed an EMIS, some of which are specifically designed for HEIs, each of these have a different focus or purpose. In addition there is limited research which provides formal guidance and best practice regarding the design of these EMIS. Studies of environmental sustainability and the role of information management in African HEIs are limited. The aim of this paper is therefore to propose a framework for the design of an EMIS for HEIs and to incorporate associated guidelines. The guidelines are based on best practice from literature and are classified according to the common components and responsibilities of an EMIS identified by several authors. This paper also highlights the increasing importance of environmental information and EMIS to environmental sustainability efforts at HEIs.

The next section provides a concise description of the research objectives and the methodology that was employed in this study. This is followed in Sect. 3 by a rigorous literature review that highlights that the design of an effective EMIS is critical to any attempt at reducing any negative environmental impact. The analysis of literature identified several common components of EMIS and resulted in the proposed theoretical framework for EMIS at HEIs. The last section provides several conclusions and recommendations for future research.

2 Research Objectives and Methodology

It has been reported that there is limited formal guidance or frameworks for HEIs that wish to adopt environmental sustainability practices, particularly for the management of environmental information (Bero et al. 2012). The main research objective of this paper is therefore: "*To propose and implement a framework that supports the design of an efficient EMIS at an HEI*." In order to derive this model, two secondary objectives must be achieved:

- Propose an architectural framework for EMIS in higher education
- Propose guidelines for the components and responsibilities of an EMIS

In order to address the objectives and produce the artefacts (the framework and guidelines), this research used the Design Science Research (DSR) methodology which is used frequently in IS' projects producing artefacts (Hevner 2007). A careful rigorous investigation into literature, previous research and extant systems was done in order to gain an understanding of the research domain. This allowed for the identification of some of the key components of an EMIS and their responsibilities as well as guidelines for the design and implementation of an EMIS. The theoretical guidelines can be used to guide the design of an EMIS.

3 Components of Environmental Management Information Systems

The adoption of EMISs as tools to support environmental efforts has been found to be most prominent in industries that have a significant impact on the environment. Such industries include pharmaceuticals, oil, hazardous chemicals, automotive, utilities, primary metals and semiconductors industries. The challenges faced by HEIs are slightly different to those of industrial contexts and are (Alshuwaikhat and Abubakar 2008; Bero et al. 2012; EPA 2007):

- An extremely diverse community of faculty, students, staff, and support personnel, all with differing priorities, modes of engagement, and supervisory models
- A broad range of institutional activities and facilities including offices, laboratories, machines, classrooms, dining halls, and dormitories
- Broad distribution across a range of buildings and facilities of differing design and age, potentially dispersed over a large area
- Relatively limited financial and personnel resources for developing, implementing, and sustaining an effective EMS and EMIS

Any sustainability efforts must include a planning phase where the institution's stakeholder's such as top management and the IT department establish policies and objectives of their EMS (UNECE 2014). At this stage the environmental indicators (for example, energy and water) must be identified and prioritised. The Global Reporting Initiative (GRI) is a popular standard for establishing environmental indicators in industry (GRI 2013). Non-institutional organisations usually have a main focus which determines their environmental indicators, for example pharmaceutical companies would have their environmental indicators focused on hazardous waste. By contrast, HEIs have a broad set of institutional activities and facilities including offices, laboratories, operating machinery, classrooms, dining halls, dormitories, and maintenance, hence environmental indicators associated with HEIs are generally more diverse. The ISO14000 set of standards produced by the International Standards Organisation (ISO 2004) is one which is frequently used in universities in the U.S. and Europe (Alshuwaikhat and Abubakar 2008; Jones et al. 2011). The Sustainability Tracking, Assessment and Rating System (STARS) is a voluntary, self-reporting framework for recognising and gauging sustainability performances specifically for the higher education environment (AASHE 2012). The four main focus areas of an HEI identified by STARS are (1) education and research; (2) operations; (3) planning, administration and engagement and (4) innovation. Thus, the complex structure of HEIs requires that EMISs be tailored for HEIs (Kamal and Asmuss 2013).

Once the planning stage of an EMS has been completed, the environmental information architecture must be determined (Speshock 2010). Muntean et al. (2010) propose an architectural framework for a Performance Management System (PMS) for HEIs. Such a system should provide the instruments to support the governance processes, showing the data and analysis necessary for strategic planning and control. The four main components or layers of the PMS framework are: (1) the data layer; (2) the reporting layer; (3) the analytical layer and (4) the monitoring layer. The PMS framework uses data warehousing technology to Extract, Transform and Load (ETL) the data into the lowest layer which is the data layer containing the university data warehouse (Muntean et al. 2010). The ETL processes will then allow for data aggregation, normalisation and integration. Data is extracted from various sources and is stored in the database of the data warehouse which is in the data layer. The reporting layer allows users to access and query data. In addition, the reporting layer allows for ad-hoc querying and standard report generating from the university portal and is valuable for managerial decision making. The analytical layer is a useful tool for management in decision making and strategising. This layer allows for advanced functionality such as data mining, Online Analytical Processing (OLAP), forecasting, multidimensional/OLAP analysis, data mining, text mining, forecasting, decision support and predictive modeling. The monitoring layer is for performance monitoring of data from the various pools of data where meaningful information is displayed by means of performance dashboards and scorecards. A performance dashboard is an application that allows stakeholders to measure, monitor and manage organisation performance more effectively. The university portal forms part of the presentation layer which is the hub of all the university IT applications and services needed by students, administrators, faculty and staff (Bero et al. 2012; Muntean et al. 2010).

A further argument for extending the PMS framework to the domain of environmental sustainability is that its architecture has similar components to those of an EMIS identified by several studies (Bero et al. 2012; El-Gayar and Fritz 2006; Giesen et al. 2009; Gunther et al. 2004). The study of Gunther et al. (2004) also uses data warehousing technology and has been successfully used for analysing and querying environmental information.

An EMIS can be described as the system that maintains and enhances the environmental knowledge base of a company in order to meet the information needs of its environmental professionals (Al-Ta'ee et al. 2013). An EMIS has also been defined as the backbone or a precondition to environmental management efforts which supports the organisation's EMS and meets the reporting needs of stakeholders (El-Gayar and Fritz 2006). Accordingly, the definitions of EMIS are very broad and can incorporate a broad selection of systems and components from stand-alone end-user systems (for example, spreadsheets) to more complex, intelligent systems to enterprise wide integrated IS and can include performance management (Bero et al. 2012).

Typically an EMIS is implemented in a large organisation where there are several data sources which are characteristically located in different physical locations and diverse implementations (El-Gayar and Fritz 2006). These organisations already have other IS in place to automate aspects of the organisation, for example legacy systems and/or Enterprise Resource Planning (ERP) systems. A comparison of three EMISs revealed several common features and differences. The Adaptive Intelligent Service Layer for Environmental information management (AISLE) is one such service-oriented EMIS that mediates between environmental data providers and actual end user applications that require pre-processed environmental information (Athanasiadis 2006). The Sustainable Online Reporting Model (STORM) is a web-based EMIS that is used mainly for sustainability reporting (Solsbach et al. 2010). Sustainability reporting efforts are tightly associated with EMISs just as much as environmental management efforts are. Sustainability reporting requires that environmental information is retrieved from the various information sources and EMISs serve this particular purpose in sustainability reporting efforts. STORM seeks to address such issues and can retrieve data for reporting from legacy information systems and other databases or sensor networks.

All three systems investigated (STORM, AISLE and DEMS) have data collection capabilities which include pulling data from various sources. However, the level of capability within the data collection component varies. The AISLE system focuses on providing high quality data hence it performs extensive data pre-processing as data is collected. The DEMS has the capability of distributed manual entry of data. All three have a central database in which they store data. However, STORM and DEMS do not allow for access to this raw data but AISLE can provide access to the data to third party end-user applications which then process the data to provide valuable information. The main focus of STORM is for external, stakeholder sustainability reporting. It is thus evident that the objectives for EMIS can vary.

An analysis of several studies of environmental information efforts and EMIS design (Bero et al. 2012; El-Gayar and Fritz 2006; Giesen et al. 2009; Muntean et al. 2010; Su et al. 2013) reveal several commonly identified components (Table 1). These components can be classified into five commonly identified categories of components of an EMIS, namely:

- Data collection
- Centralised data storage and access
- Data processing and analysis
- Reporting (ad-hoc querying)
- Monitoring

The first component category of an EMIS is the data collection component which includes the integration of legacy and heterogeneous systems (Bero et al. 2012; Giesen et al. 2009). Data collection mechanisms vary depending on the legacy systems or the lack of legacy systems but can include those used for data acquisition and data pre-processing such as data cleaning, validation, integration and normalisation. Data from automated systems with environmental sensors or smart meters can be retrieved automatically and directly from the systems and streamed to the appropriate tables in the data layer of the EMIS (Bero et al. 2012; Su et al. 2013). However, many environmental metrics cannot be collected by automated systems and must be entered onto paper based records and then captured manually, often leading to duplication in effort and errors (Bero et al. 2012). A goal of an efficient EMIS is to streamline distributed manual data collection "at the source" using specialised web-based interfaces or with a handheld tablet or device. Spatial data types such as transportation and parking must also be accommodated.

Table 1 Components of EMIS

Component category	Component	Authors
Data collection	Automated data collection (sensors, sensor networks, smart meters)	Bero et al. (2012), El-Gayar and Fritz (2006), Su et al. (2013)
	Distributed data entry at location	Bero et al. (2012)
	Legacy system integration, connectivity to enterprise or ERP systems	Bero et al. (2012), Giesen et al. (2009)
	Data cleaning, validation and verification Integration and normalisation Extract, Transform and Load (ETL)	Athanasiadis (2006), Solsbach et al. (2010), Speshock (2010), Su et al. (2013)
Centralised data storage and access	Data layer (storage layer; data warehouse layer)	Athanasiadis (2006), Bero et al. (2012)
Reporting	Reporting layer (querying and reporting)	El-Gayar and Fritz (2006), Giesen et al. (2009), Solsbach et al. (2010), Su et al. (2013)
Data processing and analysis	Analytical layer (Analysis/analytical tools, OLAP, data mining and forecasting)	Al-Ta'ee et al. (2013)
	Aggregation, simulation, modelling of data and decision support	Bero et al. (2012), El-Gayar and Fritz (2006), Giesen et al. (2009), Speshock (2010)
Monitoring	Monitoring layer (dashboards and scorecards)	Bero et al. (2012)
Presentation	Presentation layer (public access)	Su et al. (2013)

One other key role that EMISs play in sustainability reporting is the verification of the environmental information to be published (Solsbach et al. 2010). The data also needs to be validated at the source, integrated and normalised where necessary. ETL processes such as cleaning and integrating also need to take place to prepare the data for the data warehouse.

Centralised data storage and access is another commonly identified component in an EMIS (Athanasiadis 2006; Bero et al. 2012) and in the PMS architecture for HEIs proposed by Muntean et al. (2010). After the retrieval of the data from the various data sources, data can be stored and processed to produce meaningful information (Athanasiadis 2006). Some EMIS are also developed to cater for document management since in environmental efforts documents such as environmental policies need to be stored in a safe and secure environment. The reporting component is also an important component and essential to an EMIS (El-Gayar and Fritz 2006; Giesen et al. 2009; Solsbach et al. 2010; Su et al. 2013). Reporting of sustainability information can foster public participation, social responsibility and promotion of sustainability in teaching and research (Alshuwaikhat and Abubakar 2008).

Another commonly identified component category and responsibility of an EMIS is data processing and analysis. Organisations need to process environmental data into useful information which can be used to draw meaningful conclusions (Speshock 2010). Advanced EMIS offer the capability to analyse environmental information, simulate and provide decision support (El-Gayar and Fritz 2006). These capabilities are useful and make an EMIS valuable to the top management of any institution. Data processing further involves complex algorithms that provide aggregation, ad-hoc querying and modelling of environmental data and processes (Bero et al. 2012). This is referred to as the analytical layer in the Muntean framework which allows management to make decisions and strategise and allows for advanced functionality such as data mining, OLAP and forecasting. The monitoring layer is for performance monitoring. Tools that are available in this layer include dashboards and scorecards (Bero et al. 2012; Muntean et al. 2010). Data is then analysed and produced for information distribution to stakeholders through a presentation layer (Su et al. 2013) where there should be support for public awareness and outreach by allowing access to simplified aggregated data summaries of data for access by the public and HEI stakeholders (for example, student, staff, board members, management and government bodies).

Athanasiadis (2006) divides the components and features of a EMIS into three clusters of services, namely: the contribution services cluster, the management services cluster and the distribution services cluster. Based on the definition of these clusters and an analysis of their responsibilities, the four common categories components of an EMIS can be classified into these clusters. Data collection and centralised data storage can be classified in to the contribution services cluster while data processing, monitoring and reporting fall under the managerial services cluster. The distribution services cluster is responsible for access to data by stakeholders and presentation of data. In the contribution services cluster there needs to be support for allocating resource usage to buildings and campus facilities such as sports grounds and departments (Bero et al. 2012). Apportionment modifiers are used to algorithmically apportion meter utility usage to arbitrary buildings and spaces within a metered loop (Bero et al. 2012). This data is stored in the space/location entity in the data source layer. The resulting framework can be used to design an EMIS for HEIs and shows all the components (Fig. 1). The related guidelines for the components of an EMIS are summarised in Appendix.

4 Conclusions and Recommendations

This paper proposed a framework which can assist HEIs to improve their environmental information management efforts and provides guidelines for the components of an EMIS which can therefore assist with designing an EMIS. An improvement in EIM can facilitate on improvement in decision making, environmental awareness and community involvement. This study forms part of a larger research study which aims to design and develop a university-wide environmental information data warehouse. The development of the data warehouse is focused on making environmental data accessible for querying and to end user applications.

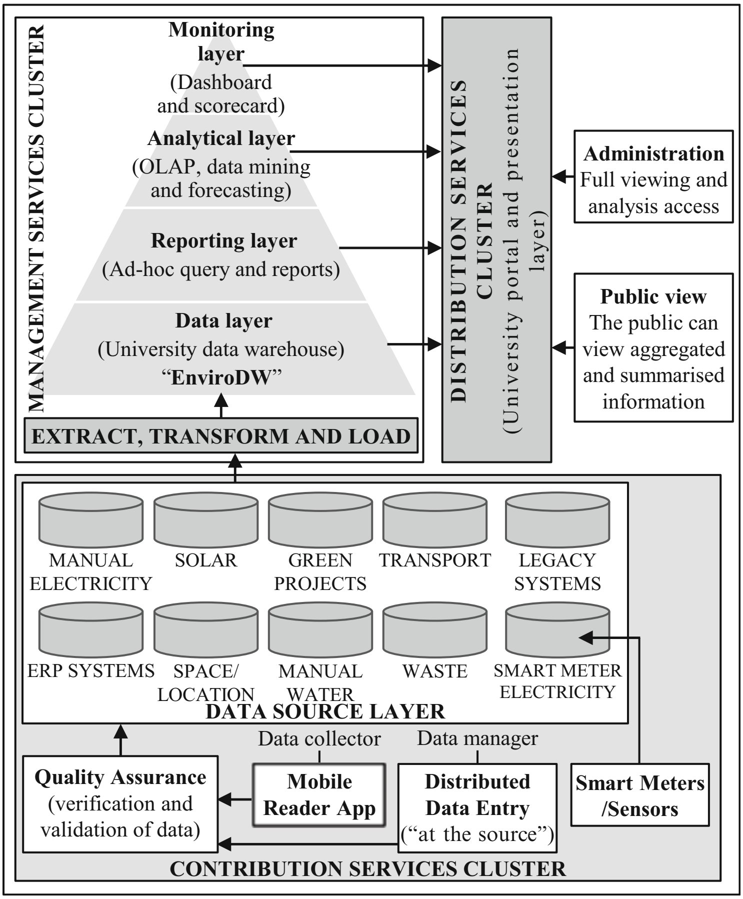

Fig. 1 A framework for EMIS design in HEIs

This will allow for the development of innovative end user applications to serve as the portal for which stakeholders can access the environmental information and view it in a meaningful way. This research is to serve as proof-of-concept in a hope to drive senior management to support and drive towards creating an environmentally sustainable institution and an inclusive community.

The development of the fully analytical tools to support senior management in decision management is important. Future research can be done to evaluate this theoretical framework in other higher education institutions. Research is required regarding the adoption of EMIS and criteria for evaluating these systems. Improving the effectiveness of EMIS and improving the changes of successful implementation will ultimately improve the success of environmental efforts. Generally HEIs are publically funded therefore transparency regarding environmental impact is of utmost importance.

Appendix: Guidelines for the Components of an EMIS

Guideline	Authors
Contribution services cluster	
There is a need for centralised storage of environmental information in an HEI	Athanasiadis (2006), Bero et al. (2012), Muntean et al. (2010)
HEIs need a computerised process for capturing environmental data (e.g. water and electricity meter readings)	Bero et al. (2012)
HEIs need to automate environmental data collection processes where possible (e.g. sensor based collection; smart meters)	Bero et al. (2012), Su et al. (2013)
It is important that HEIs perform quality assurance (data validation and verification) on environmental data collected at the source	Athanasiadis (2006)
Management services cluster	
Environmental sustainability reporting should be stakeholder oriented and automated wherever possible	Disterheft et al. (2012), Solsbach et al. (2010)
Data analytics and monitoring of environmental information should be provided	Al-Ta'ee et al. (2013), Bero et al. (2012), Muntean et al. (2010)
Simplified aggregated data summaries of environmental information must be available	Bero et al. (2012)
Data processing should be provided (ad-hoc querying, modelling of data and decision support)	Bero et al. (2012)
There should be support for allocating resource usage to buildings and campus facilities such as sports grounds and departments (apportionment modifiers)	Bero et al. (2012)
Distribution services cluster	
There should be support for public awareness and outreach by allowing access to simplified aggregated data summaries of system data for access by HEI stakeholders (student, staff, board members, management, government bodies, etc.)	Jones et al. (2011), Bero et al. (2012)
Third party applications should be granted access to environmental information where possible	Athanasiadis (2006), Bero et al. (2012)

References

AASHE (2012) STARS: version 1.2 technical manual. Association for the advancement of sustainability in higher education. AASHE, Denver

Alshuwaikhat HM, Abubakar I (2008) An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. J Clean Prod 16 (16):1777–1785

Al-Ta'ee M, El-Omari NK, Ghwanmeh S (2013) Innovative study utilizing EMIS in supporting participatory urban decision making process in Jordan. Int J Appl Inf Syst 5(2):1–13

Athanasiadis IN (2006) An intelligent service layer upgrades environmental information management. IT Prof 8(3):34–39

Bero BN, Doerry E, Middleton R, Meinhardt C (2012) Challenges in the development of environmental management systems on the modern university campus. Int J Sustain High Educ 13(2):133–149

Bosire S (2014) A sustainability reporting framework for a higher education Institution. Dissertation, Nelson Mandela Metropolitan University

Department of Higher Education and Training (2014) Regulations for reporting by public higher education institutions. Government Gazette 37726

Disterheft A, da Silva Caeiro SS, Ramos MR, de Miranda Azeiteiro UM (2012) Environmental Management Systems (EMS) implementation processes and practices in European higher education institutions—top-down versus participatory approaches. J Clean Prod 31:80–90

El-Gayar O, Fritz BD (2006) Environmental Management Information Systems (EMIS) for sustainable development: a conceptual overview. Commun Assoc Inf Syst 17:756–784

EPA (2007) Environmental Management Systems (EMSs) for colleges and universities. http://www.epa.gov/region1/assistance/univ/emsguide.html. Accessed 05 July 2014

EPA (2009) Information access strategy. http://www.epa.gov/nationaldialogue/FinalAccessStrategy.pdf. Accessed 29 June 2014

Fonseca A, Macdonald A, Dandy E, Valenti P (2011) The state of sustainability reporting at Canadian universities. Int J Sustain High Educ 12(1):22–40

Giesen N, Farzad TH, Marx Gómez J (2009) A component based approach for overall Environmental Management Information Systems (EMIS) integration and implementation. Shaker Verlag, Berlin

GRI (2013) Indicator protocols set environment (EN). https://www.globalreporting.org/resourcelibrary/G3.1-Environment-Indicator-Protocols.pdf. Accessed 10 May 2014

Gunther S, Marx Gómez J, Rautenstrauch C (2004) Modeling of a data warehouse system for environmental information. In: Proceedings of the world automation congress, Seville, Spain, 28 June–1 July 2004

Hevner AR (2007) A three cycle view of design science research a three cycle view of design science research. Scand J Inf Syst 19(2):1–5

ISO (2004) ISO 14000—environmental management. http://www.iso.org/iso/home/standards/management-standards/iso14000.htm. Accessed 04 June 2014

Jones N, Panoriou E, Thiveou K, Roumetiotis S, Allan S, Clark JRA, Evangelinos KI (2011) Investigating benefits from the implementation of Environmental Management Systems in a Greek university. Clean Techn Environ Policy 14(4):669–676

Kamal ASM, Asmuss M (2013) Benchmarking tools for assessing and tracking sustainability in higher educational institutions: identifying an effective tool for the University of Saskatchewan. Int J Sustain High Educ 14(4):449–465

Muntean M, Sabau G, Bologa A, Surcel T, Florea A (2010) Performance dashboards for universities. In: Proceedings of the 2nd international conference on manufacturing engineering, quality and production systems, Constantza, Romania, 3–5 Sept 2010

Savely SM, Carson AI, Delclos GL (2007) An environmental management system implementation model for U.S. colleges and universities. J Clean Prod 15(7):660–670

Scholtz B, Calitz A, Jonamu B (2014) A gap model for environmental information management in an African Higher Education Institution. In: Proceedings of the 8th IDIA international development informatics association conference, Port Elizabeth, South Africa, 3–4 Nov 2014

Solsbach A, Supke D, Wagner vom Berg B, Marx Gómez J (2010) Sustainability online reporting model—a web based sustainability reporting software. In: Golinska P, Fertsch M, Marx Gómez J (eds) Information technologies in environmental engineering, new trends and challenges, vol 3, Environmental science and engineering. Springer, Heidelberg, pp 165–177

Speshock CH (2010) Empowering green initiatives with IT: a strategy and implementation guide. Wiley, New Jersey

Su X, Shao G, Vause J, Tang L (2013) An integrated system for urban environmental monitoring and management based on the environmental internet of things. Int J Sust Dev World 20 (3):205–209

UNECE (2014) United Nations economic commission of Europe. http://www.unece.org/env/welcome.html. Accessed 26 June 2014

Velazquez L, Munguia N, Sanchez M (2005) Deterring sustainability in higher education institutions: an appraisal of the factors which influence sustainability in higher education institutions. Int J Sustain High Educ 6(4):383–391

Velazquez L, Munguia N, Platt A, Taddei J (2006) Sustainable university: what can be the matter? J Clean Prod 14(9–11):810–819